UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

CONTROL OF THE LODGEPOLE NEEDLEMINER

AN E C W PROJECT

OF THE

YOSEMITE NATIONAL PARK IN

1 9 3 5

by
K. A. Salman
Berkeley, California
January 10, 1936

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Forest Insect Laboratory
Berkeley - California
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FOREWORD

A summary of the 1935 control work has been considered necessary in order to determine the developments in machinery, methods, effectiveness and policy of control of the lodgepole needle-miner that have occurred up to this time. It would be difficult to progress further without reviewing conditions or without determining the known basis on which we may develop future work.

For the convenience of those lacking the time or inclination to read this paper in its entirety, a short, pointed summary is provided at the end of the report.

There has been considerable indecision and uncertainty as to what extent measures for the control of the lodgepole needle-miner are justified. For that reason the first part of the report has been given over to describing the conditions that have been the result of needleminer activity and to discussing present conditions. This has been done as a prelude to statements concerning the action it appears necessary to follow to protect the natural features represented by the lodgepole stands, the investments in improvements and the values of those stands for recreational use, from further inroads. These statements of policy have been framed in an attempt to meet the necessities of the situation from an entomological standpoint, and to comply with the objectives of the various divisions of the National Park Service.

Grateful acknowledgement is made to Colonel C. G. Thomson, Superintendent of the Yosemite National Park and to the members of the Forestry and Emergency Conservation Work Divisions of the Park personnel, for their interest and action in behalf of the control work. In particular I wish to thank Mr. Mackie, Supervisor of Entomology in the California Department of Agriculture, for his valuable advice and aid in the technical details of spray application.

Figures 1B, 2 and 4 were taken by Mr. Patterson who developed the plates, enlargements and prints for this report.

TABLE OF CONTENTS

CONTROL OF THE LODGEPOLE NEEDLEMINER

AN ECW PROJECT OF THE YOSEMITE NATIONAL PARK IN 1935

Technical Direction by the Berkeley Laboratory,
Division of Forest Insect Investigations,
United States Bureau of Entomology and Plant Quarantine

INTRODUCTION

Early in 1935 the National Park Service purchased expensive equipment in the form of a high power sprayer. In July of the same year additional investment was made in 3000 gallons of highly refined petroleum oil and in materials for emulsifying that oil. At about the same time, the United States Army, in the course of its administration of supply and supervision of camp affairs of the Civilian Conservation Corps, established a 25-man stub camp at Porcupine Creek. The National Park Service staffed the camp with competent foremen. The basis for these purchases and this action lies in the results of a few preliminary experiments conducted by the Bureau of Entomology and Plant Quarantine two years ago. (1) The purpose of these preparations was to attempt prevention of natural but undesirable changes in the forest cover of certain areas of the Yosemite National Park that are caused by the activities of a small insect - the lodgepole needleminer, (Recurvaria milleri Busck.).

The cause of these changes is not new. In some of the earliest records following establishment of the Yosemite National Park under the administration of the United States Army, observers noted the presence of extensive areas of dead lodgepole pine. These probably resulted from previous needleminer attacks (2).

The need for preventing those changes in some areas is a relatively new development. The presence of extensive ghost forests composed chiefly of bleached snags in areas devoted to the education of the citizenry of this country furnishes an excellent example of the ruthlessness of natural forces. However, in certain areas, the need for green forest cover to serve as shelter for camps and to supply the peace of mind and tranquility that is the object of many of the people seeking enjoyment in the forests, cannot be denied. As long as transportation difficulties prevented penetration of all but a relatively few individuals into the High Sierra areas affected by needleminer defoliations, there was no necessity for aiding in the maintenance of this cover. With the improvements of roads, the increasing popularity for out-door vacations, the increasing intensity of use of those areas set aside for camping and the limited number of satisfactory

(1) Salman, K. A. Preliminary Tests of Sprays for the Control of the Lodgepole Needleminer. January 17, 1934

(2) Patterson, J. E. Forest Insect Problems of the Yosemite National Park. Mimeographed Circular of the National Park Service. December 1, 1935.

areas of sufficient size to satisfy demands, there has been developed a definite need for maintaining the trees in and around areas of present or future intensive use in the healthiest condition possible. It is the purpose of spray control to prevent, as much as possible, the depletion of cover on those areas that is the result of needleminer activity.

HOW THE NEEDLEMINER INJURES TREES

Every individual needleminer requires two years to develop from the egg through the adult stage. Practically all individuals of the species are to be found in the same stage at about the same time. As a result eggs were found in August, 1935. Larvae will be present until July, 1937 and adult moths will be in flight during the latter part of July and August of that year.

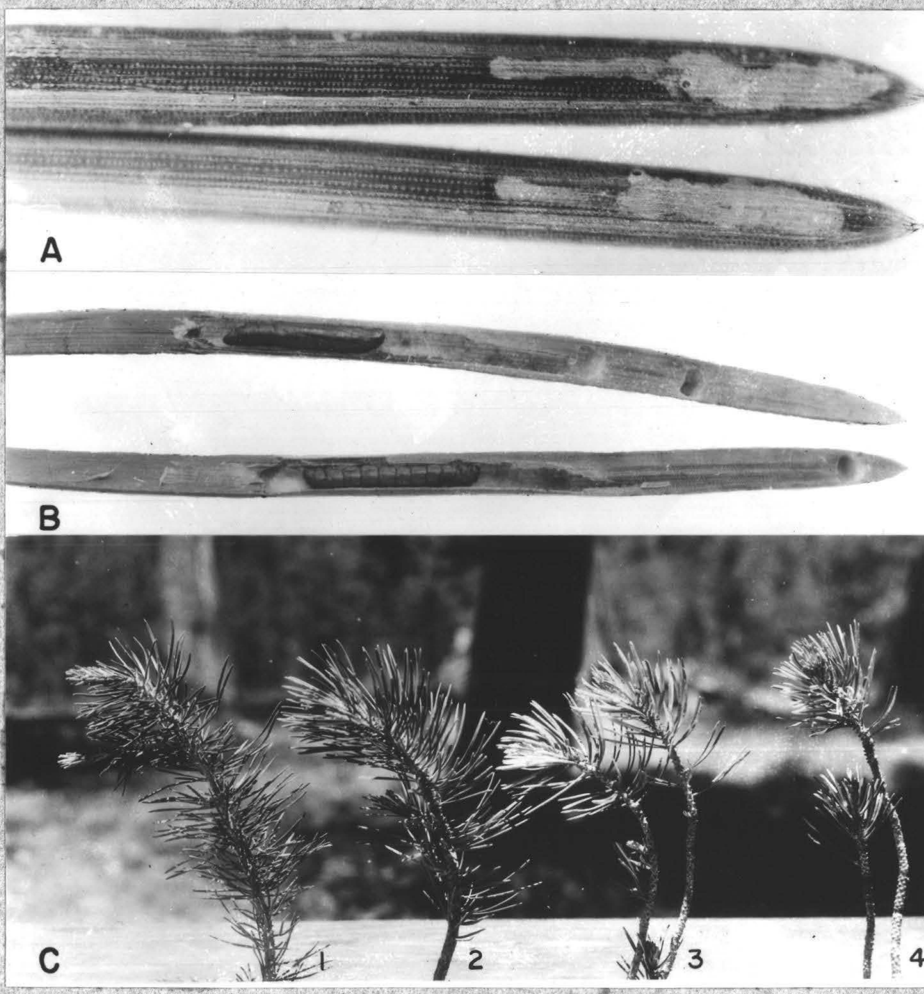

Figure 1

The larval stages do all the injury and kill the needles by mining out the material inside them. The small larval mines scarcely can be seen except under magnification (Fig.1A). As the larvae continue their work, they mine out several needles, finally becoming full grown and pupating (Fig. 1B) in the last one mined.

The effects of this work on infested trees is shown by loss of foliage. This influences the health of trees and of stands in proportion to the number of generations that have infested the trees and in proportion to the intensity of the infestations. Light or moderate infestations (Fig. C1, C2) results in little injury to the trees. Continued or heavy infestations (Fig. C3, C4) result in an almost complete loss of needles and, in spite of new growth produced from the food reserves in the trees, rapidly starves them to death.

THE EFFECTS OF DEFOLIATIONS ON STANDS

An excellent example of the effects of repeated defoliations on whole stands is to be found in Tuolumne Meadows, an area now subjected to intensive use as a campground and in which expenditures for physical improvements have been heavy.

Figure 2

Trees on the slopes south of Tuolumne Meadows had a brownish tinge as early as 1912. Needleminer activity continued with variable intensity, accompanied by scattered though lethal attacks by the mountain pine beetle, until 1919 (Fig. 2). At that time trees in a belt around the Meadows and extending from just

within the timber margin up to the 9000 foot contour were either dead or dying. Foliage on those trees in which life remained was sparse. Small branches and tips were dead. Needleminer activities glazed the panorama with a rust-colored film. Throughout the belt of infestation trees wasted away and died in spite of an abundance of life giving light and moisture. Only the youngest and most thrifty trees survived the wholesale slaughter.

Today, 23 years after the initial attacks were made and 16 years after the greatest amount of damage had been completed, evidence of the force of the destruction remains unchanged in its major aspects.

Figure 3

One view of the campground areas (Fig.3), which is but partially included in the 1919 view, shows the dead trees as stark, naked snags devoid of bark and small limbs. When seen at a distance they form a band of grayish desolation replacing the rusty hue of 16 years ago. However, a few slight changes have occurred. Some snags have fallen. Some have been felled in the interests of safety. A few of the less seriously affected trees have recovered. The small trees, in the sapling and pole stage at the time the attacks were made, have grown sufficiently to partially but inadequately replace the mature trees that were lost in the single period of epidemic infestations.

That single period of infestations has been sufficient to marthe attractiveness of the setting for recreational purposes for 16 years. The scars of the loss will probably remain for some time to come. Only through man's efforts and through growth of surviving trees has this stand been made habitable and safe for use as a campground.

The Tuolumne Meadows area did not feel the full force of the epidemics. There appears to be almost a certainty that the series of epidemic infestations now in the process of formation will not pass by the remnants of the stand left in this area. Observations made in 1907 indicated infestations in that year were in stands left untouched or slightly damaged by previous epidemic cycles. At the present time infestations are to be found above the 9000' contour, which appeared to be the upper limit of the infestations existing from 1903 to 1921, and in areas such as Merced Lake and Porcupine Flat that were left relatively undamaged by these infestations. It appears to be merely a matter of time before the natural spread of the infestations will include the Tuolumne Meadows area. South of the Merced Canyon needleminers now are found where they have never been observed before.

The full force of needleminer infestations, coupled with supplementary barkbeetle attacks, can result in desolation of a much more lasting and destructive type then occurred in Tuolumne Meadows. This type of injury has occurred in several areas (Fig. 4). It is probable that it will occur in other areas that will be necessary for accommodation of future recreational developments.

Figure 4

Porcupine Flat is one campground area, the future of which is being jeopardized by infestations now engaged in killing the trees. The trees in that area, left living following a series of epidemic needleminer infestations and the sympathetic reactions

the mountain pine beetle, are beginning to show the effects of more recent infestations by the needleminer. In addition, barkbeetle activity appears to be centering in the areas that have been subjected to moderatly heavy infestations by the 1933 and 1935 broods of the needleminer.

Figure 5, taken in 1935, shows a part of the main campground. The effects of previous infestations, which occurred some

Figure 5

time ago and which were not considered severe, are shown by the dead trees in the center of the picture and by the small dead branches that are to be seen on the tree in the left foreground. The dead trees are the results of severe defoliations followed by barkbeetle attacks. The dead branches are the minimum results of infestations on vigorous trees.

At the present time foliage on practically all the trees is sparse and sickly. During the season when the larvae are feeding actively and are more than half grown, the entire scene has a sickly

straw-colored or light reddish tinge due to the color of the fading and dead needles. Activities of but two broods have been sufficient to weaken some trees beyond any reasonable hope of recovery. It is evident that, with continuation of the attacks and loss of needles, this area will be practically denuded of those trees on which the value of the area as a campground depends. What is happening here is but a forerunner of what will happen in other valuable areas when the needleminer extends its depredations.

A CONTROL POLICY

Up to this point the purpose of the discussion has been to describe the manner in which injury is caused by the needleminer activities, the extent of the damage that has been caused by past infestations, and the course present infestations are taking. Inasmuch as the National Park Service is charged with the maintenance of natural conditions, so far as that is consistent with the public use and enjoyment, it is necessary that it be determined what place control of the needleminer should take in the performance of that duty.

The course and results of infestations are natural phenomena. However, when these results are detrimental to the use of areas as campgrounds or for other recreational developments, they are not consistent with public use and enjoyment. It is under such conditions that regulatory measures meet the needs of the public. It is under such conditions that the needs of the public overshadow the necessity or even the desirability of maintaining strictly natural conditions.

The policy to be followed in the control of the needleminer seems clear. It is stated concisely in sections 1 and 3 (3, page 23) of the Insect Control Policy formulated by the Branch of Forestry of the National Park Service. The present and future requirements of the public in using and enjoying the areas of the types mentioned in that policy makes it necessary that intensive management displace natural processes.

Fortunately the life history and activities of the needleminer are considered to be of such a nature as to make possible the protection of small areas. There appears to be no need for extensive buffer zones of protection. The three requirements for protection are:-

1. Adequate methods for the control of the insect.
2. Adequate detection of infestations needing regulation.
3. Sustained control practice where needed, for as long as it is necessary and at the periods of time during which the best results can be secured.

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3. Manual of the Branch of Forestry, National Park Service. Mimeographed Report, July 19, 1935.

DEVELOPMENT OF PROTECTION METHODS

In 1933 it was first conceived that protection of small areas, or even of individual trees, was possible. The lige history of the needleminer, which allows migration from tree to tree or area to area for but a short period of time every other year, makes this possible. No, or at least very little movement from tree to tree and no movement from area to area is possible during the greater portion of the time consumed by a single generation in reaching maturity.

The requirements for control methods were outlined at that time as follows:-

1. They must be adapted to the physical conditions of stands and topography found in areas in which protection is necessary.
2. They must not be injurious to wild life.
3. They must not create a hazard to use by vacationists.
4. They must be effective in reducing injury to the point where the natural resistance of trees or of stands is capable of overcoming the injury.

Because of these requirements, experiments conducted in 1933 included tests of substances that are non-toxic to man and animals in the forms or concentrations at which they were applied. Without knowledge of the limits of resistance of trees to defoliation, the greatest amount of control it was possible to secure was the aim of the work. It was found petroleum sprays, directed against the younger larval stages, gave a considerable and apparently satisfactory control. These sprays, used judiciously, also met the other requirements of control of the needleminer in park areas.

All of the work conducted in 1933 and 1934 was done by hand equipment and was entirely experimental. Although cost of control of the needleminer in park areas is, within limits, a minor factor in determining its practicability, no data was secured on that phase of the work in 1933. In addition definite information on the adaptability of equipment of sufficient size and power to meet the requirements of the work was lacking. Accordingly the 1935 work, in addition to testing spray substances experimentally (4,5), was expanded to include field tests using large equipment. The purpose of the work was to secure cost figures and to determine if it was possible to spray under the conditions existing in the lodgepole areas.

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4. Salman, K.A. and G.S.Hensill. Notes on the Life History of the Lodgepole Needleminer. November 25, 1935.
5. Salman, K.A. and G.S.Hensill. Experiments in the Control of the Lodgepole Needleminer. December 17, 1935.

RESULTS OF THE 1935 FIELD WORK

EXTENT OF THE WORK

Fourteen plots in the vicinity of Porcupine Creek and Porcupine Flat, were surveyed, staked and mapped. The location of these plots is shown in the map accompanying this report. General observations were made on the stand density and on the height of trees on each plot. The same spray, a 4% tank-mixed emulsion composed of light medium oil, blood albumin emulsifier and water, was applied on all the plots. Application started on August 5 and continued, with some interruptions until September 25. An attempt was made to conduct this operation on the same basis that would be used in ordinary control.

COSTS

A foreman was supplied to keep the records of production and to supervise the work. The two men employed by the Bureau of Entomology and Plant Quarantine, who were engaged in experimental work, gave general supervision to the technical details of the project. This overhead was necessary chiefly because of the experimental nature of the work. Accordingly, none of the time spent by these three men is included in the computation of man-hours expended on the work.

Details of the acreages and stand characteristics of each plot are given in Table I. The man-hours spent in applying the spray as well as the amounts of materials applied to each plot also are given. This information has been broken down to an acreage basis and averages are given for the 59 acres covered by the work. Although applications on some plots evidently are too light or too heavy, I believe the average figures given in the table are sufficient to serve as a basis in determining the costs of materials and labor in spraying an average acre.

EQUIPMENT

For the most part four CCC enrollees satisfactorily served the spray unit and applied the sprays. When an extra supply unit was used, five men were necessary. The efforts of the enrollees from the two CCC camps (Merced Grove and Crane Flat) were praiseworthy. Although inexperience was a factor of considerable importance, the work of the truck drivers from both camps and of the nozzleman from the Crane Flat camp was much better than had been hoped for.

The spray outfit was mounted as a complete working unit on a 3-ton Studebaker truck. This transportation equipment was equal to the task of carrying the load and of maneuvering when off the road. A much greater freedom of action than had been expected was secured.

When no supply unit was used, water was taken by the refiller directly from Porcupine Creek. This process is shown in Figure 6.

Figure 6

It soon became evident that water sources during the summer season may neither be abundant nor satisfactory. Accordingly a supplementary supply unit consisting of a $1\frac{1}{2}$ ton Chevrolet truck on which was mounted a 500 gallon tank was used to meet the situation. This equipment was filled at a central point be means of a semi-portable gasoline pump. Although it is certain that a similar supply unit will be necessary in future work, the equipment used this summer cannot be considered satisfactory.

Experience gained early in the work with the spraying unit made evident the fact that successful spraying is dependent on the use of a unit of adequate size and capacity. The spray unit must function with maximum efficiency as a result of correct design of all parts and of coordination of operation of all the minute details of construction from the power plant to the extreme tip of the nozzle. In high power spraying the importance of details of design and manufacture of the machinery and accessories cannot be stressed too much. It is evident that few, if any, power sprayers are entirely correct in design of all their parts or that the accessories are made to secure the maximum nozzle pressure that is possible with the available power. The type of spray and, in tree spraying, the distance to which it is thrown are factors of extreme importance. Performance at the gun depends to a great extent on the nozzle pressure.

It is evident that the greatest possible efficiency was not secured from the equipment used in this season's work. The equipment, when not discharging, showed the maximum pressure on the pump gauge and threw a satisfactory spray to the tops of the average trees. However, there was little, if any margins of power left over to throw a spray to the tops of larger trees or to offset winds that cut down the height to which spray can be thrown. That greater height can be secured by increasing the R.P.M. of the pump is shown in figures 7 and 7A. The greater height shown in the latter figure was secured by holding down the governor while the nozzle was open.

Figure 7

Figure 7A

The friction caused by 100 feet of hose was not sufficient to make it difficult to reach the tops of trees with the spray. However, sufficient height could not be secured when the spray had to pass through 200 feet of the 3/4 inch hose.

Three spray guns (Fig. 8) were available and tests were made to determine their usefulness on this work.

Figure 8

Figure 9

The Hardie, which was furnished with the spray unit, was found to be the least satisfactory of the three. The Worthley gun, which originally was designed for shade tree spraying, proved the better gun for ordinary work on tall trees. However, good coverage was not secured on the smaller trees and poles due to the fact that its stream is adapted only for solid stream spraying. Typical results secured with this gun are shown in Figure 9.

The Bean gun proved to be the one best adapted for much of the work. It has the most satisfactory and least tiring type of shutoff. In addition it has a twist valve that enables the operator to vary the type of spray delivered to the trees. When the valve is entirely open a solid stream spray capable of reaching the tops of average trees is available for use. (Fig. 10A) When the valve is partially open (Fig. 10B) a finely divided spray is projected that results in excellent coverage of poles and small trees. When entirely closed (Fig. 10C) it delivers a cone type of mist spray that is very satisfactory for covering reproduction and poles.

Although the model tested did not throw the spray as high as the Worthley gun, a new model is available that has eliminated some of the evident mistakes that were made in the manufacture of the older type. The adaptability of this gun and its ability to change to meet conditions, makes it of much greater general use than either of the other two guns that were tested.

Figure 10A

Figure 10B (Upper)
Figure 10C (Lower)

In addition to the tests of gun types, tests of three different types of nozzles were made. These types are shown in Figure 11.

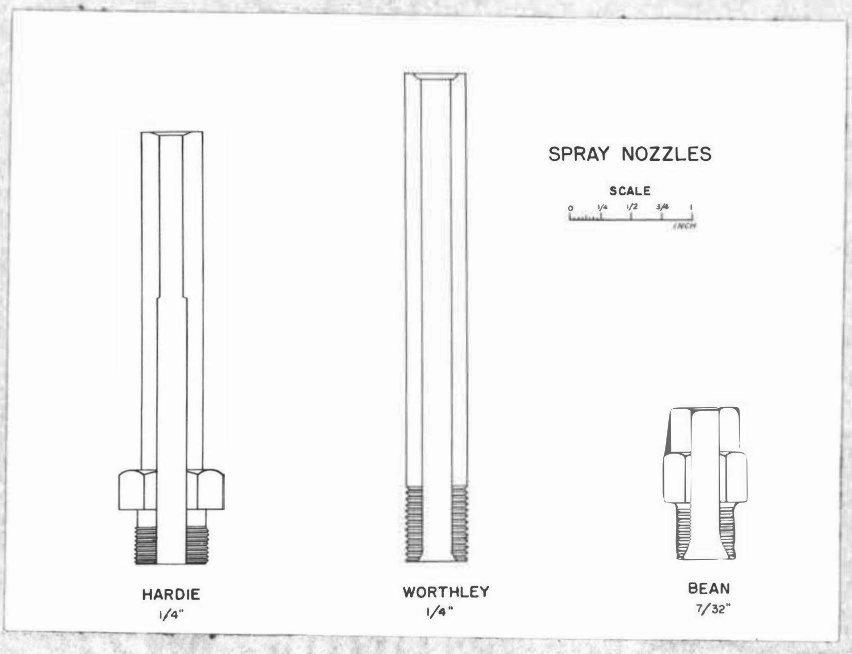


Figure 11

Details in the construction and in the scale show the differences in the three types. The Worthley, which is a straight-bored type, 4 inches in length and which has a right angled orifice margin, gave the best results.

CONTROL SECURED

It was not possible to secure samples from all the plots and determine the amount of control secured. However, a sufficient number of samples were obtained from plots 10, 11, and 12.

Control was evidenced in two ways. Mortality in egg and larval stages before the mines were started is shown by a reduction in the percent of needles infested. This control amounted to 25.5 percent on plot 10, none on plot 11, and 50.2 percent on plot 12. These differences have been correlated with the presence of certain brood stages and vary because of that and the extreme variation in infestation, even on different branches of the same tree.

The second type of control is determined by the mortality of the larval brood. This amounted to 82.4 percent on plot 10, 27.2 percent on plot 11, and 30.7 percent on plot 12. These results are, or course, control in addition to that shown b y reduction in infestation.

Although what practically amounted to crude oil was applied at a 12 percent concentration in the small scale experiments, absolutely no injury resulted to the foliage. Some foliage injury was found on plots 4 and 10. The injury on plot 4 was slight while that on plot 10 was much more severe. However, no damage resulted that was greater than that which would have resulted from needleminer attacks.

High temperatures appear to have been the chief cause of this foliage injury. On both plots the sprays were applied just preceding a period of high temperatures. Additional proof that this is the cause of the injury is furnished by the fact that the more severely injured trees were situated on the north side of granite sand openings from which the heat was reflected. It is possible a portion of the injury may be due to double coverage, the second spray having been applied after the first had dried. This would build up an abnormally heavy oil film. It also is possible that weakness or lack of vitality in certain trees aided in producing injury that would not ordinarily have appeared on healthy trees.

GENERAL RECOMMENDATIONS

It is extremely difficult, in view of the uncertainties in policies and resources that might be applied in furthering this work, to formulate a definite program.

It is certain that the Yosemite National Park cannot allow the values represented by or invested in campgrounds to deteriorate. It is also certain that satisfactory methods of preventing that deterioration have not yet been given an adequate basis through experimentation or practice.

It is suggested that the present and future campground, administrative and recreational areas in lodgepole stands be determined and definitely set apart as areas for intensive protection. The spread of infestations should be determined so that plans may be made in advance of heavy infestations.

It is evident that the work concerned with the protection of areas of intensive use that carry lodgepole stands has but just begun. It is further evident that the problem is not of the type in which the necessary research can be done by casual or part time attention. The control of this pest is of great importance to the future satisfactory condition of many park facilities and developments. Before efficient control can be secured, much more research must be done on the technical phases of the problem that serve as a basis for formulating field control methods.

We know nothing of the amount of control that it is necessary to secure to protect the stands. There is little known concerning the effects of spraying on the larger larval stages of the insect. There are many substances that have not yet been tried to detemaine if they would be effective. I suggest that these phases of the problem receive adequate attention.

It is to be hoped that the present equipment, working at its greatest efficiency, will be equal to the job. Under"Specific Recommendations" suggestions are made as to what changes may be advisable in secureing greater efficiency. It is possible a larger and more powerful unit may be necessary. Tests should be made in an attempt to secure the maximum efficiency of the present equipment. To my mind the union of efforts of an entomologist and of a skilled mechanic would be advantageous. The former should be capable of judging the performance from an entomological standpoing. The latter should be capable of making the required changes and of determining the probabld results.

SPECIFIC RECOMMENDATIONS

These specific recommendations deal largely with the operation of equipment and with personnel. They are recommendations intended to improve performance.

1. In future work care must be exercised in selecting the crew personnel, particularly the nozzleman. Time and money will be wasted unless it is understood every man is not fitted for the work.

2. It will be necessary to develop a spray unit that includes satisfactory and efficient equipment to perform the servide of supply.

3. It is suggested that water supplies be developed at convenient points in areas in which spraying may be necessary during the course of the present series of epidemic infestations.

4. A detachable traction tread may be of considerable aid in allowing greater freedom of action of the truck in the field.

5. An accurate test should be made of the pressure guage that is mounted on the pump.

6. It is evident that, with some modification of the equipment, a much greater efficiency can be secured from the pump unit. However, the capacity of the equipment should be considered carefully before changes are made. The job is one for a skilled engineer or mechanic.

7. Friction must be reduced in the discharge line. There is no need for the right angled turns or dead ends. Better shutoff valves could be installed. Less reduction in the diameter of the line is possible if one inch hose is used in spraying.

8. The reduction in friction resulting from installation of one inch hose may result in greater effective pump pressures. It is suggested that this installation be tried.

9. Guns and nozzles need more testing and development.

SUMMARY

1. The cause of changes in forest cover resulting from the attacks of the lodgepole needleminer is not new. The need for preventing those changes in some areas is new.

2. Needleminer infestations result in defoliation. Defoliation, carried on to the extent and over the long period typical of epidemic cycles, causes the death of trees from starvation.

3. In Tuolumne Meadows, an area of great importance for use as a campground and for recreation, the results of the seriesoof infestations that lasted from 1903 to 1921 still are in evidence.

4. This and similar areas that did not feel the full force of previous infestations are probably certain of future attack and destruction.

5. When the full force of needleminer infestations is exerted, almost complete destruction of the mature stands results.

6. Destruction of the stands on a valuable campground area at Porcupine Flat now is occurring as a result of recent infestations. Epidemic infestations now occur in areas that never before were infested or that suffered but slightly from previous attacks.

7. Although destruction of this type is a natural phenomenon, the requirements of the public and the necessity of maintaining cover on campground areas of present or future intensive use, makes control of the lodgepole needleminer on those areas a necessary type of regulation.

8. It is suggested that the park policy, as regards needleminer control embrace the following points:

- a. Continued cooperation in developing adequate control methods.
- b. Development of an adequate detection system.
- c. Application of sustained control progress in areas of present and future intensive use.

9. The development of protection methods is discussed and the various phases of the 1935 work, particularly those concerned with the use of spraying equipment and the results of spray applications, are described.

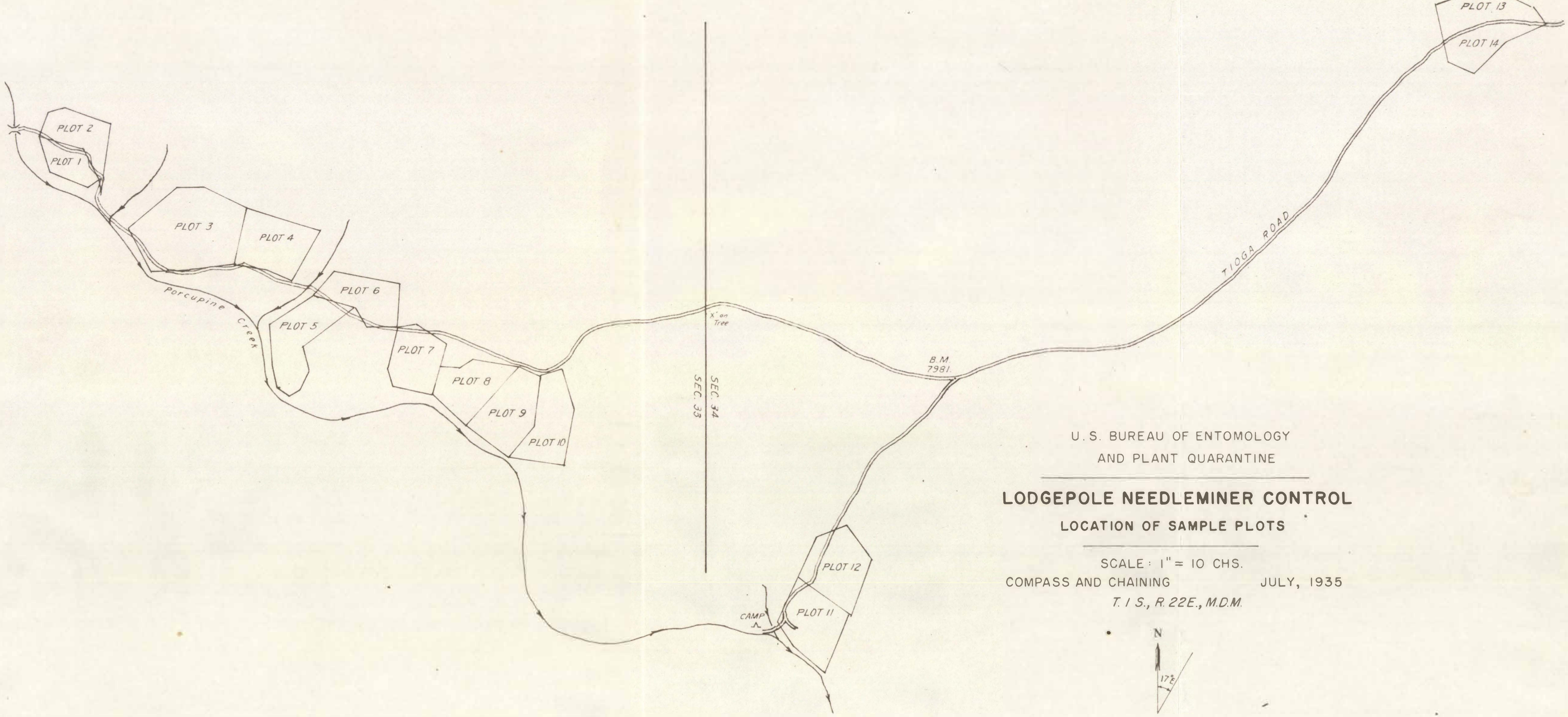
10. Recommendations are made for future work.

TABLE I

Plot No.	Acres	Stand Conditions: Density	Stand Conditions: Height	Plot Applications: Man Hours	Plot Applications: Gals. Spray	Plot Applications: Gals. Oil	Plot Applications: Lbs. Spreader	Acre Applications: Man Hours	Acre Applications: Gals. Spray	Acre Applications: Gals. Oil	Acre Applications: Lbs. Spreader
1	1.73	Light Average	Below Average	23.3	1690	73.2	4.50	13.5	977	42.3	2.6
2	4.01	Average	Above "	20.3	2790	120.0	7.50	5.1	696	29.9	1.9
3 +	8.60	Average	Above "	40.0	4185	180.0	11.25	4.7	487	20.9	1.3
4	4.88	Light	Average	47.5	3255	140.0	8.75	9.7	667	28.7	1.9
5	4.57	Average	"	35.3	4185	180.0	11.25	7.7	916	39.4	2.5
6	3.60	Light	Below "	14.0	1595	70.0	4.33	3.9	443	19.4	1.2
7 +	3.44	Average	Average	24.0	3255	140.0	8.75	7.0	946	40.7	2.5
8	3.69	Above Average	Above "	34.0	3720	160.0	10.00	9.2	1008	43.4	2.7
9 +*	4.67	Above Average	" "	52.5	5315	230.0	14.35	11.2	1138	49.3	3.1
10	3.95	Average	" "	45.2	4820	206.8	12.75	11.4	1220	52.4	3.2
11	4.47	Light	" "	36.0	3945	170.0	10.66	8.1	883	38.0	2.4
12	4.33	Average	" "	25.3	2790	120.0	7.50	5.8	644	27.7	1.7
13 +	3.95	Dense	Below "	15.0	1195	50.0	3.10	3.8	303	12.7	0.8
14	3.05	Dense	" "	24.7	3720	160.0	10.00	8.1	1220	52.4	3.3
Totals	58.94			437.1	46,460	2,000.0	124.67				
Averages								7.4	788	33.9	2.1

+ Supplementary Tank Truck used to supply water in the spraying of these plots.

* Two applications of spray were made on this plot. The first, averaging but about 15 gallons of oil applied per acre was considered insufficient to secure proper coverage.



U. S. BUREAU OF ENTOMOLOGY
AND PLANT QUARANTINE

LODGEPOLE NEEDLEMINER CONTROL

LOCATION OF SAMPLE PLOTS

SCALE: 1" = 10 CHS.

COMPASS AND CHAINING JULY, 1935

T. 1 S., R. 22 E., M.D.M.